CLAIMS

What is claimed is:

1. A method for binarizing an image having *N* columns and *M* rows of pixels and a first column forming a first edge of the image, a last column forming a second edge of the image opposite the first edge, a first row of the image forming a third edge of the image and a last row of the image forming a fourth edge of the image opposite the third edge, said method producing an array of binarized pixels; said method comprising:

(a) initializing, for each column of the image, a first variable representing a local column low pixel value and a second variable representing a local column high pixel value, and, for each row of the image, a third variable representing a local row low pixel value and a fourth variable representing a local row high pixel value;

(b) iteratively repeating steps (c) through (f) for each column of the image, from the first column to the last column;

(c) iteratively repeating steps (d) through (f) for each row of the image, from the first row to the last row;

(d) determining a threshold value dependent upon said first variable and said second variable at the column of the location index, and upon said third variable and said fourth variable at the row of the location index, the location index being dependent upon the iterated column and the iterated row;

(e) comparing a value representative of an image pixel at the location index with the determined threshold value, and

(f) setting a binarization pixel for the location index to either a first value or a second value, dependent upon results of the comparison, and adjusting values of either the first variable and the third variable, or the second variable and the fourth variable dependent upon the results of the comparison.

2. A method in accordance with Claim 1 wherein the image is a color image, said value representative of an image pixel is a gray scale value representative of the image pixel, and said method further comprises converting the color image to a gray scale image.

3. A method in accordance with Claim 2 wherein converting the color image to a gray scale image comprises converting an image represented by an RGB representation to an image represented by a YIQ representation, and said gray scale value is a YIQ_Y (luminance) value.

4. A method in accordance with Claim 2 further comprising scanning the color image to obtain the *N* columns and *M* rows of pixels.

5. A method in accordance with Claim 1 further comprising performing optical character recognition on the array of binarized pixels.

6. A method in accordance with Claim 1 wherein said first variable is written $X_{low}(i)$ for i=0, ..., N-1 and said second variable is written $X_{high}(i)$ for i=0, ..., N-1, said third variable is written $Y_{low}(j)$ for j=0, ..., M-1 and said fourth variable is written $Y_{high}(j)$ for j=0, ..., N-1, and further wherein adjusting values of either the first variable and the third variable, or the second variable and the fourth variable dependent upon the results of the comparison comprises adjusting either:

$$X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$$
$$Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$$

or:

$$X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$$
$$Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1)$$

dependent upon the results of the comparison, where:

w is a parameter,

* (asterisk) represents multiplication,

i is the column of the location index,

j is the row of the location index, and

YIQ_Y(i,j) is a luminosity value of a pixel of the image at the location index.

7. A method in accordance with Claim 6 wherein the threshold is written as:

$$T(i,j) = (X_{low}(i) + X_{high}(i) + Y_{low}(j) + Y_{high}(j))/4.$$

8. A method in accordance with Claim 7 wherein initializing said first variable, second variable, third variable and fourth variable comprises setting:

$$\begin{aligned} X_{low}(i) &= YIQ\_Y_{min}, \ i = 0,\dots,N-1 \\ X_{high}(i) &= YIQ\_Y_{max}, \ i = 0,\dots,N-1 \\ Y_{low}(j) &= YIQ\_Y_{min}, \ j = 0,\dots,M-1 \\ Y_{high}(j) &= YIQ\_Y_{max}, \ j = 0,\dots,M-1 \end{aligned},$$

where:

$$\begin{aligned} YIQ\_Y_{min} &= \text{minimum}\{YIQ\_Y(i,j)\}, \quad i = 0,\dots,N-1, \quad j = 0,\dots,M-1 \\ YIQ\_Y_{max} &= \text{maximum}\{YIQ\_Y(i,j)\}, \quad i = 0,\dots,N-1, \quad j = 0,\dots,M-1. \end{aligned}$$

9. A method in accordance with Claim 8 further comprising pretraining values of $X_{low}(i)$, $X_{high}(i)$, $Y_{low}(j)$, and $Y_{high}(j)$, utilizing a first pre-training procedure selected from the group consisting of **A_1** and **A_2**, and a second pre-training procedure selected from the group consisting of **A_3** and **A_4**, wherein pre-training procedure **A_1** is written:

A_1: *for i=N_1 to i=N_2*

for j=M_1 to j=M_2

if $YIQ\_Y(i,j) < (X_{low}(i) + X_{high}(i))/2$

then $X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$

else $X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$

pre-training procedure **A_2** is written:

A_2: *for i=N_2 down to i=N_1*

for j=M_2 down to j=M_1

if $YIQ\_Y(i,j) < (X_{low}(i) + X_{high}(i))/2$

then $X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$

else $X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$

pre-training procedure **A_3** is written

A_3: *for* $i=N\_1$ *to* $i=N\_2$

for $j=M\_1$ *to* $j=M\_2$

if $YIQ\_Y(i,j) < (Y_{low}(i) + Y_{high}(i))/2$

then $Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$

else $Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1)$

and pre-training procedure **A_4** is written

A_4: *for* $i=N\_2$ *down to* $i=N\_1$

for $j=M\_2$ *down to* $j=M\_1$

if $YIQ\_Y(i,j) < (Y_{low}(i) + Y_{high}(i))/2$

then $Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$

else $Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1)$,

wherein:

$$0 \le M\_1 \le M\_2 \le (M-1) \text{ and}$$
$$0 \le N\_1 \le N\_2 \le (N-1).$$

10. A method in accordance with Claim 8 further comprising pre-training values of $X_{low}(i)$, $X_{high}(i)$, $Y_{low}(j)$, and $Y_{high}(j)$, utilizing four pre-training procedures **A_1**, **A_2**, **A_3** and **A_4**, wherein pre-training procedure **A_1** is written:

A_1: *for* $i=N\_1$ *to* $i=N\_2$

for $j=M\_1$ *to* $j=M\_2$

if $YIQ\_Y(i,j) < (X_{low}(i) + X_{high}(i))/2$

then $X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$

else $X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$

pre-training procedure **A_2** is written:

A_2: *for i=N_2 down to i=N_1*

for j=M_2 down to j=M_1

if $YIQ\_Y(i,j) < (X_{low}(i) + X_{high}(i))/2$

then $X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$

else $X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$

pre-training procedure **A_3** is written

A_3: *for i=N_1 to i=N_2*

for j=M_1 to j=M_2

if $YIQ\_Y(i,j) < (Y_{low}(i) + Y_{high}(i))/2$

then $Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$

else $Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1)$

and pre-training procedure **A_4** is written

A_4: *for i=N_2 down to i=N_1*

for j=M_2 down to j=M_1

if $YIQ\_Y(i,j) < (Y_{low}(i) + Y_{high}(i))/2$

then $Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$

else $Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1)$,

wherein:

$$0 \le M\_1 \le M\_2 \le (M-1) \text{ and}$$
$$0 \le N\_1 \le N\_2 \le (N-1).$$

11. A computing apparatus for binarizing an image having N columns and M rows of pixels and a first column forming a first edge of the image, a last column forming a second edge of the image opposite the first edge, a first row of the image forming a third edge of the image and a last row of the image forming a fourth edge of the image,

said computing apparatus comprising a memory and a processor operatively coupled to said memory for reading and storing values therein;

said computing apparatus configured to:

(a) initialize in said memory, for each column of the image, a first variable representing a local low first direction pixel value and a second variable representing a local high first direction pixel value, and, for each row of the image, a third variable representing a local low second direction pixel value and a fourth variable representing a local high second direction pixel value;

(b) iteratively repeat (c) through (f) for each column of the image, from the first column to the last column;

(c) iteratively repeat (d) through (f) for each row of the image, from the first row to the last row;

(d) determine a threshold value dependent upon said first variable and said second variable at the column of the location index, and upon said third variable and said fourth variable at the row of a location index, the location index being dependent upon the iterated column and the iterated row;

(e) compare a value representative of an image pixel at the location index with the determined threshold value, and

(f) store, in said memory, a binarization pixel for the location index to either a first value or a second value, dependent upon results of the comparison, and adjust stored values of either the first variable and the third variable, or the second variable and the fourth variable dependent upon the results of the comparison,

wherein said iterations (b) and (c) produce an array of binarization pixels stored in said memory.

12. An apparatus in accordance with Claim 11 wherein the image is a color image, said value representative of an image pixel is a gray scale value representative of the image pixel, and said apparatus is further configured to convert the color image to a gray scale image.

13. An apparatus in accordance with Claim 12 wherein to convert the color image to a gray scale image, said apparatus is configured to convert an image represented by an RGB representation to an image represented by a YIQ representation, and said gray scale value is a YIQ_Y (luminance) value.

14. An apparatus in accordance with Claim 12 further comprising a scanner, and wherein said apparatus is further configured to scan the color image to obtain the *N* columns and *M* rows of pixels of the color image.

15. An apparatus in accordance with Claim 11 further configured to perform optical character recognition on said array of binarized pixels.

16. An apparatus in accordance with Claim 11 wherein said first variable is written $X_{low}(i)$ for i=0, ..., N-1 and said second variable is written $X_{high}(i)$ for i=0, ..., N-1, said third variable is written $Y_{low}(j)$ for j=0, ..., M-1 and said fourth variable is written $Y_{high}(j)$ for j=0, ..., N-1, and further wherein to adjust values of either the first variable and the third variable, or the second variable and the fourth variable dependent upon the results of the comparison, said apparatus is configured to adjust either:

$$X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$$
$$Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$$

or:

$$X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$$
$$Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1)$$

dependent upon the results of the comparison, where:

w is a parameter,

* (asterisk) represents multiplication,

i is the column of the location index,

j is the row of the location index, and

YIQ_Y(i,j) is a luminosity value of a pixel of the image at the location index.

17. An apparatus in accordance with Claim 16 wherein the threshold is written as:

$$T(i,j) = (X_{low}(i) + X_{high}(i) + Y_{low}(j) + Y_{high}(j))/4.$$

18. An apparatus in accordance with Claim 17 wherein to initialize said first variable $X_{low}(i)$, said second variable $X_{high}(i)$, said third variable $Y_{low}(j)$ and said fourth variable $Y_{high}(j)$, said apparatus is configured to store in said memory, the values:

$$\begin{array}{l} X_{low}(i) = YIQ\_Y_{min},\ i = 0,...,N-1 \\ X_{high}(i) = YIQ\_Y_{max},\ i = 0,...,N-1 \\ Y_{low}(j) = YIQ\_Y_{min},\ j = 0,...,M-1 \\ Y_{high}(j) = YIQ\_Y_{max},\ j = 0,...,M-1 \end{array},$$

where:

$$\begin{array}{l} YIQ\_Y_{min} = \text{minimum}\{YIQ\_Y(i,j)\},\quad i = 0,...,N-1,\quad j = 0,...,M-1 \\ YIQ\_Y_{max} = \text{maximum}\{YIQ\_Y(i,j)\},\quad i = 0,...,N-1,\quad j = 0,...,M-1. \end{array}$$

19. An apparatus in accordance with Claim 18 further configured to pretrain values of $X_{low}(i)$, $X_{high}(i)$, $Y_{low}(j)$, and $Y_{high}(j)$ stored in said memory utilizing a first pre-training procedure selected from the group consisting of **A_1** and **A_2**, and a second pre-training procedure selected from the group consisting of **A_3** and **A_4**, wherein pre-training procedure **A_1** is written:

A_1: *for i=N_1 to i=N_2*

for j=M_1 to j=M_2

if $YIQ\_Y(i,j) < (X_{low}(i) + X_{high}(i))/2$

then $X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$

else $X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$

pre-training procedure **A_2** is written:

A_2: *for* $i=N\_2$ *down to* $i=N\_1$

for $j=M\_2$ *down to* $j=M\_1$

if $YIQ\_Y(i,j) < (X_{low}(i) + X_{high}(i))/2$

then $X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$

else $X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$

pre-training procedure **A_3** is written

A_3: *for* $i=N\_1$ *to* $i=N\_2$

for $j=M\_1$ *to* $j=M\_2$

if $YIQ\_Y(i,j) < (Y_{low}(i) + Y_{high}(i))/2$

then $Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$

else $Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1)$

and pre-training procedure **A_4** is written

A_4: *for* $i=N\_2$ *down to* $i=N\_1$

for $j=M\_2$ *down to* $j=M\_1$

if $YIQ\_Y(i,j) < (Y_{low}(i) + Y_{high}(i))/2$

then $Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$

else $Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1)$,

wherein:

$$0 \le M\_1 \le M\_2 \le (M-1) \text{ and}$$
$$0 \le N\_1 \le N\_2 \le (N-1).$$

20. An apparatus in accordance with Claim 18 further configured to pretrain values of $X_{low}(i)$, $X_{high}(i)$, $Y_{low}(j)$, and $Y_{high}(j)$ stored in said memory utilizing four pre-training procedures **A_1**, **A_2**, **A_3** and **A_4**, wherein pre-training procedure **A_1** is written:

A_1: *for* $i=N\_1$ *to* $i=N\_2$

for $j=M\_1$ *to* $j=M\_2$

if $YIQ\_Y(i,j) < (X_{low}(i) + X_{high}(i))/2$

then $X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$

else $X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$

pre-training procedure **A_2** is written:

A_2: *for* $i=N\_2$ *down to* $i=N\_1$

for $j=M\_2$ *down to* $j=M\_1$

if $YIQ\_Y(i,j) < (X_{low}(i) + X_{high}(i))/2$

then $X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$

else $X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$

pre-training procedure **A_3** is written

A_3: *for* $i=N\_1$ *to* $i=N\_2$

for $j=M\_1$ *to* $j=M\_2$

if $YIQ\_Y(i,j) < (Y_{low}(i) + Y_{high}(i))/2$

then $Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$

else $Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1)$

and pre-training procedure **A_4** is written

A_4: *for* $i=N\_2$ *down to* $i=N\_1$

for j=M_2 down to j=M_1

if YIQ_Y(i,j) $<$ *(*Y_{low}*(i) +* Y_{high}*(i))/2*

then Y_{low}*(j) = (*Y_{low}*(j) * w + YIQ_Y(i,j))/(w+1)*

else Y_{high}*(j) = (*Y_{high}*(j) * w + YIQ_Y(i,j))/(w+1),*

wherein:

$$0 \le M\_1 \le M\_2 \le (M-1) \text{ and}$$
$$0 \le N\_1 \le N\_2 \le (N-1).$$

21. A machine readable medium or media having recorded thereon instructions configured to instruct a computing apparatus having a memory and a processor operatively coupled to the memory for reading and storing values therein to:

(a) initialize in the memory, for each column of an image having *N* columns and *M* rows of pixels and a first column forming a first edge of the image, a last column forming a second edge of the image opposite the first edge, a first row of the image forming a third edge of the image and a last row of the image forming a fourth edge of the image, a first variable representing a local low first direction pixel value and a second variable representing a local high first direction pixel value, and, for each row of the image, a third variable representing a local low second direction pixel value and a fourth variable representing a local high second direction pixel value;

(b) iteratively repeat (c) through (f) for each column of the image, from the first column to the last column;

(c) iteratively repeat (d) through (f) for each row of the image, from the first row to the last row;

(d) determine a threshold value dependent upon said first variable and said second variable at the column of the location index, and upon said third variable and said fourth variable at the row of a location index, the location index being dependent upon the iterated column and the iterated row;

(e) compare a value representative of an image pixel at the location index with the determined threshold value, and

(f) store, in the memory, a binarization pixel for the location index to either a first value or a second value, dependent upon results of the comparison, and adjust stored values of either the first variable and the third variable, or the second variable and the fourth variable dependent upon the results of the comparison,

wherein the iterations (b) and (c) produce an array of binarization pixels stored in the memory.

22. A medium or medium in accordance with Claim 21 wherein the image is a color image, said value representative of an image pixel is a gray scale value representative of the image pixel, and wherein said medium or media further have recorded therein instructions configured to instruct the computing apparatus to convert the color image to a gray scale image.

23. A medium or media in accordance with Claim 22 wherein to convert the color image to a gray scale image, said medium or media has recorded therein instructions configured to instruct the computing apparatus to: convert an image represented by an RGB representation to an image represented by a YIQ representation, wherein said gray scale value is a YIQ_Y (luminance) value.

24. A medium or media in accordance with Claim 22 further having recorded thereon instructions configured to scan the color image utilizing a scanner to obtain the *N* columns and *M* rows of pixels of the color image.

25. A medium or media in accordance with Claim 21 further having recorded thereon instructions configured to instruct the computing apparatus to perform optical character recognition on said array of binarized pixels.

26. A medium or media in accordance with Claim 21 wherein said first variable is written $X_{low}(i)$ for i=0, ..., N-1 and said second variable is written $X_{high}(i)$ for i=0, ..., N-1, said third variable is written $Y_{low}(j)$ for j=0, ..., M-1 and said fourth variable is written $Y_{high}(j)$ for j=0, ..., N-1, and further wherein to adjust values of either the first variable and the third variable, or the second variable and the fourth variable dependent upon the results of the comparison, said medium or media has recorded thereon instructions configured to instruct the computing apparatus to adjust either:

$$X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$$
$$Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$$

or:

$$X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j)) / (w+1)$$
$$Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j)) / (w+1)$$

dependent upon the results of the comparison, where:

w is a parameter,

* (asterisk) represents multiplication,

i is the column of the location index,

j is the row of the location index, and

YIQ_Y(i,j) is a luminosity value of a pixel of the image at the location index.

27. A medium or media in accordance with Claim 26 wherein the threshold is written as:

$$T(i,j) = (X_{low}(i) + X_{high}(i) + Y_{low}(j) + Y_{high}(j)) / 4.$$

28. A medium or media in accordance with Claim 27 wherein to initialize said first variable $X_{low}(i)$, said second variable $X_{high}(i)$, said third variable $Y_{low}(j)$ and said fourth variable $Y_{high}(j)$, said medium or media have recorded thereon instructions configured to instruct the computing apparatus to store in the memory the values:

$$\begin{aligned} X_{low}(i) &= YIQ\_Y_{min},\ i = 0,\ldots,N-1 \\ X_{high}(i) &= YIQ\_Y_{max},\ i = 0,\ldots,N-1 \\ Y_{low}(j) &= YIQ\_Y_{min},\ j = 0,\ldots,M-1 \\ Y_{high}(j) &= YIQ\_Y_{max},\ j = 0,\ldots,M-1 \end{aligned},$$

where:

$$YIQ\_Y_{min} = \text{minimum}\{YIQ\_Y(i,j)\}, \quad i=0,\ldots,N-1, \quad j=0,\ldots,M-1$$
$$YIQ\_Y_{max} = \text{maximum}\{YIQ\_Y(i,j)\}, \quad i=0,\ldots,N-1, \quad j=0,\ldots,M-1.$$

29. A medium or media in accordance with Claim 28 further having recorded thereon instructions configured to instruct the computing apparatus to pre-train values of $X_{low}(i)$, $X_{high}(i)$, $Y_{low}(j)$, and $Y_{high}(j)$ stored in the memory utilizing a first pre-training procedure selected from the group consisting of **A_1** and **A_2**, and a second pre-training procedure selected from the group consisting of **A_3** and **A_4**, wherein pre-training procedure **A_1** is written:

A_1: *for i=N_1 to i=N_2*

for j=M_1 to j=M_2

if $YIQ\_Y(i,j) < (X_{low}(i) + X_{high}(i))/2$

then $X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$

else $X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$

pre-training procedure **A_2** is written:

A_2: *for i=N_2 down to i=N_1*

for j=M_2 down to j=M_1

if $YIQ\_Y(i,j) < (X_{low}(i) + X_{high}(i))/2$

then $X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$

else $X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$

pre-training procedure **A_3** is written

A_3: *for i=N_1 to i=N_2*

for j=M_1 to j=M_2

$if\ YIQ\_Y(i,j) < (Y_{low}(i) + Y_{high}(i))/2$

$then\ Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$

$else\ Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1)$

and pre-training procedure **A_4** is written

A_4: *for i=N_2 down to i=N_1*

for j=M_2 down to j=M_1

$if\ YIQ\_Y(i,j) < (Y_{low}(i) + Y_{high}(i))/2$

$then\ Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$

$else\ Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1),$

wherein:

$$0 \le M\_1 \le M\_2 \le (M-1) \text{ and}$$
$$0 \le N\_1 \le N\_2 \le (N-1).$$

30. A medium or media in accordance with Claim 28 further having recorded thereon instructions configured to instruct the computing apparatus to pre-train values of $X_{low}(i)$, $X_{high}(i)$, $Y_{low}(j)$, and $Y_{high}(j)$ stored in said memory utilizing four pre-training procedures **A_1**, **A_2**, **A_3** and **A_4**, wherein pre-training procedure **A_1** is written:

A_1: *for i=N_1 to i=N_2*

for j=M_1 to j=M_2

$if\ YIQ\_Y(i,j) < (X_{low}(i) + X_{high}(i))/2$

$then\ X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$

$else\ X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$

pre-training procedure **A_2** is written:

A_2: *for i=N_2 down to i=N_1*

for j=M_2 down to j=M_1

if $YIQ\_Y(i,j) < (X_{low}(i) + X_{high}(i))/2$

then $X_{low}(i) = (X_{low}(i) * w + YIQ\_Y(i,j))/(w+1)$

else $X_{high}(i) = (X_{high}(i) * w + YIQ\_Y(i,j))/(w+1)$

pre-training procedure **A_3** is written

A_3: *for i=N_1 to i=N_2*

for j=M_1 to j=M_2

if $YIQ\_Y(i,j) < (Y_{low}(i) + Y_{high}(i))/2$

then $Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$

else $Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1)$

and pre-training procedure **A_4** is written

A_4: *for i=N_2 down to i=N_1*

for j=M_2 down to j=M_1

if $YIQ\_Y(i,j) < (Y_{low}(i) + Y_{high}(i))/2$

then $Y_{low}(j) = (Y_{low}(j) * w + YIQ\_Y(i,j))/(w+1)$

else $Y_{high}(j) = (Y_{high}(j) * w + YIQ\_Y(i,j))/(w+1)$,

wherein:

$$0 \le M\_1 \le M\_2 \le (M-1) \text{ and}$$
$$0 \le N\_1 \le N\_2 \le (N-1).$$